Dual Gate Field Effect Transistors as Electrical Sensors for Vapor-Phase Chemicals

Completed Technology Project (2012 - 2015)

Project Introduction

Organic materials have shown utility in a variety of gas sensing applications, owing to their excellent sensitivity and selectivity. However, many materials are only suitable for optical signaling methods, such as fluorescence or color change. Systems to read these sensors tend to be expensive and fragile. These problems can be addressed by changing the signaling method to electronic. Chemiresistors, materials that change their electronic resistance in response to the presence of an analyte, are an effective means of electronic detection, but suffer from many drawbacks. First, the change in current is directly proportional to the amount of analyte present, which limits the resolution and sensitivity. Secondly, it imposes an additional materials requirement; in addition to being both sensitive and selective to the target analyte, the sensing material must also possess good charge transport abilities, which is often problematic for organic materials. To address this issue, we propose a new device: the dual gate field effect transistor. In such a device, a semiconducting material is sandwiched between two insulating layers, followed by two gate electrodes. Two more electrodes, the source and drain, are in direct contact with the semiconductor and pass a current dependent upon the states of the two gate electrodes. The bottom gate is used to tune the threshold voltage of the top gate, ensuring the sensor operates in the optimal mode. The top gate is functionalized with organic molecules tuned to a specific analyte. The analyte will transfer charges to the organic layer, which will bias the transistor. In this implementation, the change in current is proportional to the square of the amount of analyte present. This would be a great improvement over chemiresistors. Sensitivity and selectivity are maintained by the organic molecules deposited used to functionalize the top gate. Since charge transport occurs in the semiconductor rather than the molecules used for sensing, this also eliminates the requirement that the sensor material be electrically conductive. Herein, we propose a novel electronic sensor that provides unprecedented sensitivity, while maintaining selectivity and without imposing further material constraints. This device will detect chemicals in the vapor phase and be tunable to virtually any chemical.

Anticipated Benefits

This novel electronic sensor that would provide unprecedented sensitivity, while maintaining selectivity and without imposing further material constraints. This device will detect chemicals in the vapor phase and be tunable to virtually any chemical.

Project Image Dual Gate Field Effect Transistors as Electrical Sensors for Vapor-Phase Chemicals

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Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Responsible Program:

Space Technology Research Grants

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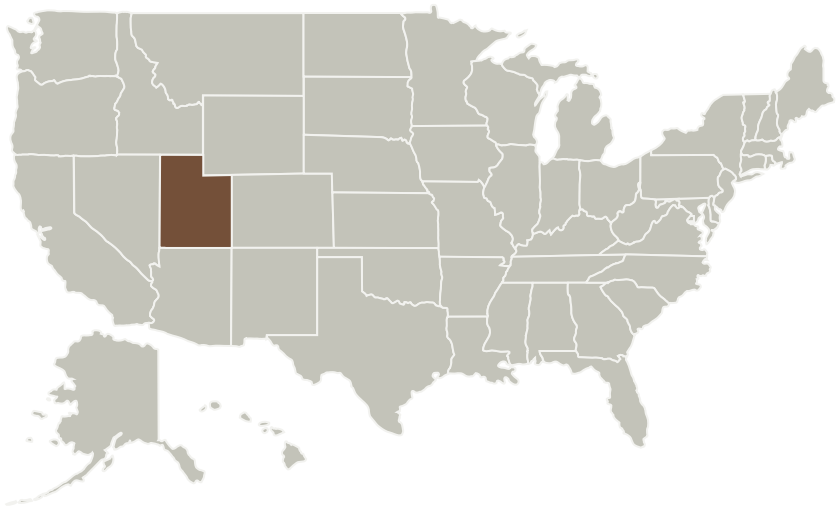
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
University of Utah	Supporting Organization	Academia	Salt Lake City, Utah

Primary U.S. Work Locations
Utah

Project Management

Program Director:
Claudia M Meyer

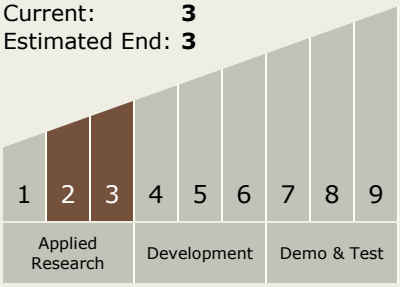
Program Manager:
Hung D Nguyen

Principal Investigator:
Ling Zang

Co-Investigator:
Benjamin R Bunes

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



Technology Areas

Primary:

- TX12 Materials, Structures, Mechanical Systems, and Manufacturing
  - TX12.1 Materials
    - TX12.1.6 Materials for Electrical Power Generation, Energy Storage, Power Distribution and Electrical Machines

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Images

11483-1363183603202.jpg
Project Image Dual Gate Field Effect Transistors as Electrical Sensors for Vapor-Phase Chemicals
(https://techport.nasa.gov/image/1760)

Project Website:

https://www.nasa.gov/directorates/spacetech/home/index.html